

An examination of Figures 4-2 through 4-5 indicates that the maximum allowable EIRP levels required to satisfy the measured performance threshold of the GPS C/A-code receiver, across all of the operational scenarios, is a function of the PRF of the UWB device. Figure 4-2 shows that the maximum allowable EIRP levels corresponding to those UWB signal permutations with a PRF of 100 kHz. The EIRP levels shown in this figure for the unmodulated, 100% gated UWB waveform was computer based on a measured break-lock threshold. For the remaining UWB signal permutations represented in the figure, neither a break-lock nor a reacquisition could be measured for UWB power levels up to the maximum power available from the UWB signal generator. For these cases, the maximum UWB signal generator power level was used to compute the EIRP level. Thus the reported EIRP level represents a lower limit for these cases. That is, the actual maximum allowable EIRP level may higher than the level shown in the figure for these 100 kHz PRF UWB waveforms. From Figure 4-2, it can be observed that the maximum EIRP levels necessary to satisfy the measured performance threshold for the C/A-code GPS receiver over all of the operational scenarios considered in this study range from -73.2 to -26.5 dBW/MHz.

Figure 4-4 shows that the maximum allowable EIRP levels necessary to satisfy the measured performance thresholds over all of the operational scenarios considered in this study range from -98.6 to -67.0 dBW/MHz for those UWB signals employing PRFs of 1 MHz, 5 MHz, and 20 MHz, that are classified as noise-like in their interference effects to the GPS C/A-code receiver.

The data presented in Figure 4-5 shows that the maximum allowable EIRP levels range from -106.9 to -70.2 dBW over all of the operational scenarios considered for those UWB signals that are classified as CW-like in their interference effects on the GPS C/A-code receiver. These EIRP levels are based on the power in a single spectral line and in order to compare to the Part 15 level, it must be assumed that only a single spectral line appears in the measurement bandwidth.

Figures 4-6 and 4-7 present summary plots showing the maximum allowable EIRP calculated for the surveying operational scenarios assuming the use of the semi-codeless receiver architecture measured in this study. The analysis results are presented as a function of the various UWB signal structures examined. For the semi-codeless receiver architecture, the interference effects of all of the UWB signals examined are classified as either pulse-like or noise-like. Figure 4-6 shows that for those UWB signals examined with a PRF of 100 kHz, the calculated maximum level EIRP is above the current Part 15 emission level (i.e. no additional attenuation is necessary) with one exception: the 20% gated, 2% relative dithered signal.

Figure 4-7 shows the for the PRF's of 1 MHz, 5 MHz, and 20 MHz, those UWB signal structures that were classified as noise-like, the maximum allowable EIRP level must be as much as 23 dB below the current Part 15 level to satisfy the measured performance threshold of the semi-codeless GPS receiver in the applicable operational scenarios. The measurements of the semi-codeless receiver indicate a relative immunity to CW-like interference effects. This is because the semi-codeless receiver architecture uses the P-code signal which, because of its longer code length, has essentially no spectral lines.

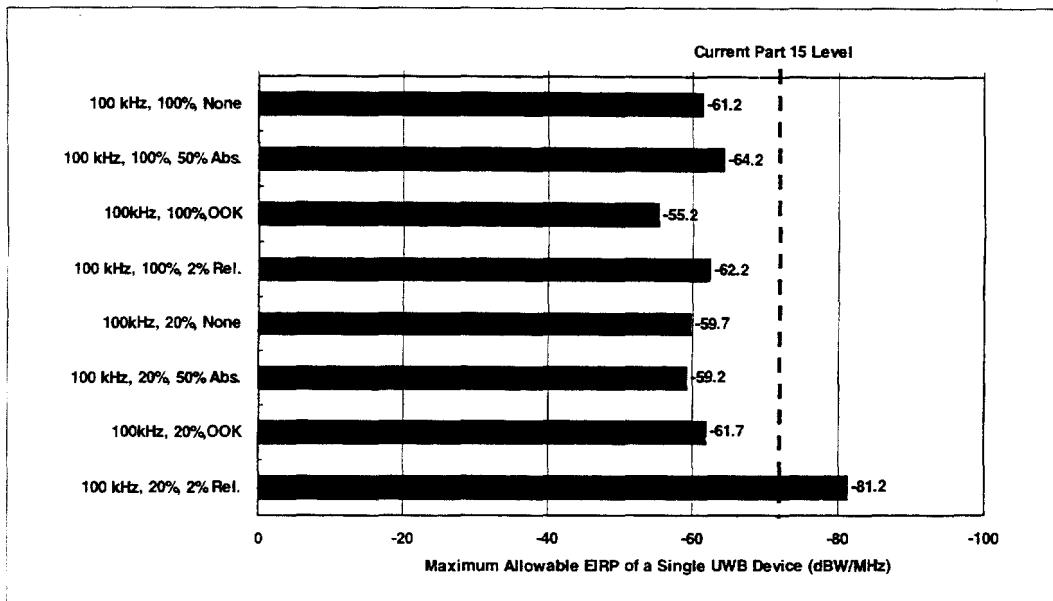


Figure 4-5. Maximum Allowable EIRP as a Function of UWB Signal Structure for the Semi-Codeless Receiver Architecture (Pulse-Like UWB Signals)

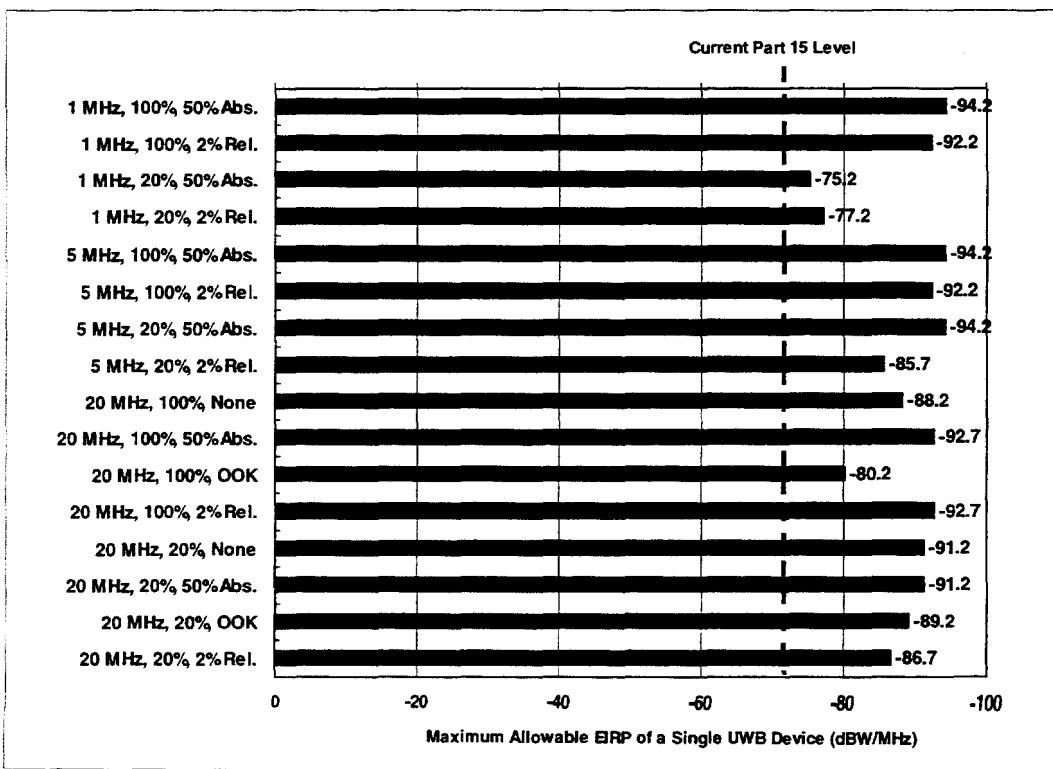


Figure 4-6. Maximum Allowable EIRP as a Function of UWB Signal Structure for the Semi-Codeless Receiver Architecture (Noise-Like UWB Signals)

### **4.3 CONCLUSIONS**

The data collected in this assessment demonstrates that when considered in potential interactions with GPS receivers used in applications represented by the operational scenarios considered in this study, some of the UWB signal permutations examined exceeded the measured GPS performance thresholds at EIRP levels well below the current Part 15 emission level. Likewise, other UWB signal permutations (e.g., the 100 kHz PRF UWB signals) only slightly exceeded, and in some cases did not exceed, the measured GPS performance thresholds when considered in potential interactions with GPS receivers defined by the operational scenarios considered as a part of this study.

The following general conclusions were drawn based on the findings of this study:

- 1) The GPS receiver performance thresholds measured within this study are consistent with the interference protection limits developed within national and international GPS study groups.
- 2) When multiple noise-like UWB signals with equivalent power levels at the GPS receiver input are considered, the effective aggregate signal level in the receiver IF bandwidth is determined by adding the average power of each of the UWB signals.
- 3) Within the limitations of this study (i.e., the available number of UWB signal generators), it was found that when multiple CW-like UWB signals are considered, the effective aggregate interference effect to a C/A-code GPS receiver is the same as that of a single CW-like signal. The interference mechanism is a result of the alignment of a UWB spectral line with a dominant GPS C/A-code line.
- 4) The CW-like interference effect is not applicable to the semi-codeless receiver examined when operating in the dual frequency mode.
- 5) A GPS antenna does not offer any additional attenuation to that portion of a UWB signal within the GPS frequency band.
- 6) For those UWB signals examined with a PRF of 100 kHz, maximum permissible EIRP levels between -73.2 and -26.5 dBW/MHz are necessary to ensure EMC with the GPS applications defined by the operational scenarios considered within this study.
- 7) For those UWB signals examined with a PRF of 1 MHz, the maximum allowable EIRP levels necessary to achieve EMC with the GPS receiver applications considered in this study range from -70.2 to -104.3 dBW for the CW-like (unmodulated) UWB waveforms, and -57.6 to -91.6 dBW/MHz for the noise-like (modulated and/or dithered) UWB waveforms.
- 8) For those UWB signals examined with a PRF of 5 MHz, the maximum allowable EIRP levels necessary to ensure EMC with the GPS receiver applications considered in this study range from

-70.7 to -106.1 dBW for the CW-like (non-dithered) UWB waveforms, and from -49.6 to -97.6 dBW/MHz for the noise-like (dithered) UWB waveforms.

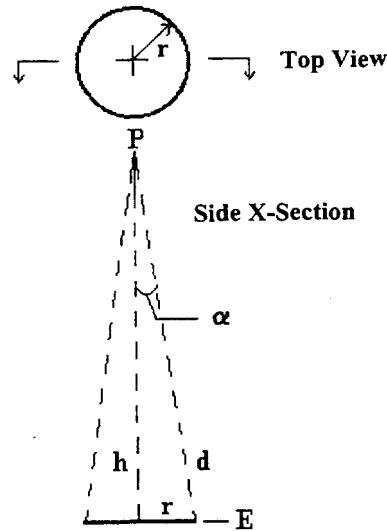
9) For those UWB signals examined with a PRF of 20 MHz, the maximum allowable EIRP levels required to ensure EMC with all of the GPS receiver applications considered in this study range from -71.0 to -106.9 dBW for the CW-like (non-dithered) UWB waveforms, and from -60.0 to -98.6 dBW/MHz for the noise-like (dithered) UWB waveforms.

It must be noted that these results are applicable only to those UWB signal permutations examined within this study and to those applications of GPS that are defined by the operational scenarios presented for consideration herein.

## APPENDIX A

### Derivation of Equations for Aggregate Effects Of UWB Devices in the Non-Precision Approach Landing Operational Scenario

This appendix provides the derivation of the equations used to compute the aggregate effects of UWB devices in the non-precision approach operational scenario. The parameters used to derive the equations are shown in Figure A-1.



**Figure A-1**

The parameters in Figure A-1 are defined as:

Point P is the airborne GPS receiver antenna;

Surface E is the plane containing the interfering sources;

h is the minimum distance from point P to plane E

d is the distance from points on plane E whose propagation loss differs from the minimum loss at distance h by a fixed pathloss ratio LR;

r is the radius circle containing the points of the fixed pathloss ratio; and  
 $\alpha$  is the angle between lines h and d.

Let  $d/h = (LR)^{0.5}$

Then

$$d^2 = r^2 + h^2 = h^2(LR)$$

$$r^2 = h^2(LR) - h^2$$

$$r^2 = h^2(LR-1)$$

The radius of the circle containing the interfering sources is given by:

$$r = h(LR-1)^{0.5}$$

To derive the equation for computing the angle  $\alpha$  use the trigonometric relationship for the cosine:

$$\cos \alpha = h/d$$

$$\alpha = \cos^{-1} (h/d) = \cos^{-1} (1/(LR)^{0.5})$$

The pathloss is proportional to  $20 \log d = 20 \log (h(LR)^{0.5})$ . This can be rewritten as

$$20 \log d = 20 \log h + 10 \log LR$$

## **Appendix B**

### **Results of Spreadsheet Analysis Program**

## B-2

### Operational Scenario: Terrestrial GPS Receiver and Single UWB Device

#### GPS Receiver Architecture: C/A-code

UWB EIRP (dBW/MHz)																GPS Receiver Criteria					
UWB PRF		UWB Gating		UWB Mod		Imax (dBW/MHz)	Hgps (m)	Huwb (m)	Hsep (m)	Theta (deg)	Gr (dBc)	Dmin (m)	Lp (dB)	Lmult (dB)	Lallot (dB)	Lman (dB)	Laf (dB)	Lba (dB)	Lsm (dB)		
<b>Broadband Noise</b>																	-95.1	RQT			
UWB	UWB	UWB	UWB	UWB	UWB	Imax (dBW)	Hgps (m)	Huwb (m)	Hsep (m)	Theta (deg)	Gr (dBc)	Dmin (m)	Lp (dB)	Lmult (dB)	Lallot (dB)	Lman (dB)	Laf (dB)	Lba (dB)	Lsm (dB)	UWB EIRP (dBW)	
1 MHz	100%	None	-134.5	3	3	2	0	0	0	2	42.4	0	0	3	0	0	0	0	0	-104.3	BL
5 MHz	100%	None	-143.7	3	3	2	0	0	0	2	42.4	0	0	3	0	0	0	0	0	-106.1	BL
20 MHz	100%	None	-145.5	3	3	2	0	0	0	2	42.4	0	0	3	0	0	0	0	0	-105.6	BL
5 MHz	20%	None	-145	3	3	2	0	0	0	2	42.4	0	0	3	0	0	0	0	0	-105.8	BL
20 MHz	20%	None	-145.2	3	3	2	0	0	0	2	42.4	0	0	3	0	0	0	0	0	-106.4	BL
5 MHz	100%	OOK	-145.8	3	3	2	0	0	0	2	42.4	0	0	3	0	0	0	0	0	-105.1	BL
20 MHz	100%	OOK	-144.5	3	3	2	0	0	0	2	42.4	0	0	3	0	0	0	0	0	-105.1	BL
5 MHz	20%	OOK	-144.2	3	3	2	0	0	0	2	42.4	0	0	3	0	0	0	0	0	-104.8	BL
20 MHz	20%	OOK	-146.3	3	3	2	0	0	0	2	42.4	0	0	3	0	0	0	0	0	-106.9	BL
<b>UWB PRF</b>																	UWB EIRP (dBW/MHz)	GPS Receiver Criteria			
100 kHz	100%	None	-112.6	3	3	2	0	0	0	2	42.4	0	0	3	0	0	0	0	-73.2	BL	
100 kHz	20%	None	-106.5	3	3	2	0	0	0	2	42.4	0	0	3	0	0	0	0	-67.1	DNBL	
1 MHz	20%	None	-97.6	3	3	2	0	0	0	2	42.4	0	0	3	0	0	0	0	-58.2	DNBL	
100 kHz	100%	OOK	-102.6	3	3	2	0	0	0	2	42.4	0	0	3	0	0	0	0	-63.2	DNBL	
1 MHz	100%	OOK	-121.2	3	3	2	0	0	0	2	42.4	0	0	3	0	0	0	0	-81.8	BL	
100 kHz	20%	OOK	-109.4	3	3	2	0	0	0	2	42.4	0	0	3	0	0	0	0	-70.0	DNBL	
1 MHz	20%	OOK	-101.1	3	3	2	0	0	0	2	42.4	0	0	3	0	0	0	0	-61.7	DNBL	
100 kHz	100%	50% Abs.	-100	3	3	2	0	0	0	2	42.4	0	0	3	0	0	0	0	-60.6	DNBL	
1 MHz	100%	50% Abs.	-113	3	3	2	0	0	0	2	42.4	0	0	3	0	0	0	0	-73.6	RQT	
5 MHz	100%	50% Abs.	-137	3	3	2	0	0	0	2	42.4	0	0	3	0	0	0	0	-97.6	RQT	
20 MHz	100%	50% Abs.	-138	3	3	2	0	0	0	2	42.4	0	0	3	0	0	0	0	-98.6	RQT	
100 kHz	100%	2% Rel.	-100	3	3	2	0	0	0	2	42.4	0	0	3	0	0	0	0	-60.6	DNBL	
1 MHz	100%	2% Rel.	-131	3	3	2	0	0	0	2	42.4	0	0	3	0	0	0	0	-91.6	RQT	
5 MHz	100%	2% Rel.	-136.5	3	3	2	0	0	0	2	42.4	0	0	3	0	0	0	0	-97.1	RQT	
20 MHz	100%	2% Rel.	-136	3	3	2	0	0	0	2	42.4	0	0	3	0	0	0	0	-96.6	RQT	
100 kHz	20%	50% Abs.	-107	3	3	2	0	0	0	2	42.4	0	0	3	0	0	0	0	-67.6	DNBL	
1 MHz	20%	50% Abs.	-97.5	3	3	2	0	0	0	2	42.4	0	0	3	0	0	0	0	-58.1	DNBL	
5 MHz	20%	50% Abs.	-105	3	3	2	0	0	0	2	42.4	0	0	3	0	0	0	0	-65.6	RQT	
20 MHz	20%	50% Abs.	-135	3	3	2	0	0	0	2	42.4	0	0	3	0	0	0	0	-95.6	RQT	
100 kHz	20%	2% Rel.	-107	3	3	2	0	0	0	2	42.4	0	0	3	0	0	0	0	-67.6	DNBL	
1 MHz	20%	2% Rel.	-97	3	3	2	0	0	0	2	42.4	0	0	3	0	0	0	0	-57.6	RQT	
5 MHz	20%	2% Rel.	-89	3	3	2	0	0	0	2	42.4	0	0	3	0	0	0	0	-49.6	DNBL	
20 MHz	20%	2% Rel.	-133	3	3	2	0	0	0	2	42.4	0	0	3	0	0	0	0	-93.6	RQT	

BL - Break-Lock

RQT - Reacquisition Time

DNBL - Did not break-lock at the maximum UWB generator signal power

**Operational Scenario: Terrestrial GPS Receiver and Multiple UWB Device (Outdoor Operation)**

**GPS Receiver Architecture: C/A-code**

Broadband Noise			Imax (dBW/MHz)	Hgps (m)	Huwb (m)	Hsep (m)	Theta (deg)	Gr (dBc)	Dmin (m)	Lp (dB)	Lmult (dB)	Lallot (dB)	Lman (dB)	Laf (dB)	Lba (dB)	Lsm (dB)	UWB EIRP (dBW/MHz)	Single Entry GPS Receiver Criteria
UWB PRF	UWB Gating	UWB Mod.	Imax (dBW)	Hgps (m)	Huwb (m)	Hsep (m)	Theta (deg)	Gr (dBc)	Dmin (m)	Lp (dB)	Lmult (dB)	Lallot (dB)	Lman (dB)	Laf (dB)	Lba (dB)	Lsm (dB)	UWB EIRP (dBW)	
1 MHz	100%	None	-143.7	3	3	10	0	0	10	56.4	0	3	3	0	0	0	-93.4	BL
5 MHz	100%	None	-145.5	3	3	10	0	0	10	56.4	0	3	3	0	0	0	-95.2	BL
20 MHz	100%	None	-145	3	3	10	0	0	10	56.4	0	3	3	0	0	0	-94.7	BL
5 MHz	20%	None	-145.2	3	3	10	0	0	10	56.4	0	3	3	0	0	0	-94.9	BL
20 MHz	20%	None	-145.8	3	3	10	0	0	10	56.4	0	3	3	0	0	0	-95.5	BL
5 MHz	100%	OOK	-144.5	3	3	10	0	0	10	56.4	0	3	3	0	0	0	-94.2	BL
20 MHz	100%	OOK	-144.5	3	3	10	0	0	10	56.4	0	3	3	0	0	0	-94.2	BL
5 MHz	20%	OOK	-144.2	3	3	10	0	0	10	56.4	0	3	3	0	0	0	-93.9	BL
20 MHz	20%	OOK	-146.3	3	3	10	0	0	10	56.4	0	3	3	0	0	0	-96.0	BL
UWB PRF	UWB Gating	UWB Mod.	Imax (dBW/MHz)	Hgps (m)	Huwb (m)	Hsep (m)	Theta (deg)	Gr (dBc)	Dmin (m)	Lp (dB)	Lmult (dB)	Lallot (dB)	Lman (dB)	Laf (dB)	Lba (dB)	Lsm (dB)	UWB EIRP (dBW/MHz)	GPS Receiver Criteria
100 kHz	100%	None	-112.6	3	3	10	0	0	10	56.4	0	3	3	0	0	0	-62.3	BL
100 kHz	20%	None	-106.5	3	3	10	0	0	10	56.4	0	3	3	0	0	0	-56.2	DNBL
1 MHz	20%	None	-134.5	3	3	10	0	0	10	56.4	6	3	3	0	0	0	-90.2	NRQT
100 kHz	100%	OOK	-102.6	3	3	10	0	0	10	56.4	0	3	3	0	0	0	-53.3	DNBL
1 MHz	100%	OOK	-134.5	3	3	10	0	0	10	56.4	6	3	3	0	0	0	-90.2	NRQT
100 kHz	20%	OOK	-109.4	3	3	10	0	0	10	56.4	0	3	3	0	0	0	-59.1	DNBL
1 MHz	20%	OOK	-134.5	3	3	10	0	0	10	56.4	6	3	3	0	0	0	-90.2	NRQT
100 kHz	100%	50% Abs.	-100	3	3	10	0	0	10	56.4	0	3	3	0	0	0	-49.7	DNBL
1 MHz	100%	50% Abs.	-134.5	3	3	10	0	0	10	56.4	6	3	3	0	0	0	-90.2	NRQT
5 MHz	100%	50% Abs.	-137	3	3	10	0	0	10	56.4	6	3	3	0	0	0	-92.7	RQT
20 MHz	100%	50% Abs.	-138	3	3	10	0	0	10	56.4	6	3	3	0	0	0	-93.7	RQT
100 kHz	100%	2% Rel.	-100	3	3	10	0	0	10	56.4	0	3	3	0	0	0	-49.7	DNBL
1 MHz	100%	2% Rel.	-134.5	3	3	10	0	0	10	56.4	6	3	3	0	0	0	-90.2	NRQT
5 MHz	100%	2% Rel.	-136.5	3	3	10	0	0	10	56.4	6	3	3	0	0	0	-92.2	RQT
20 MHz	100%	2% Rel.	-136	3	3	10	0	0	10	56.4	6	3	3	0	0	0	-91.7	RQT
100 kHz	20%	50% Abs.	-107	3	3	10	0	0	10	56.4	0	3	3	0	0	0	-56.7	DNBL
1 MHz	20%	50% Abs.	-134.5	3	3	10	0	0	10	56.4	6	3	3	0	0	0	-90.2	NRQT
5 MHz	20%	50% Abs.	-134.5	3	3	10	0	0	10	56.4	6	3	3	0	0	0	-90.2	NRQT
20 MHz	20%	50% Abs.	-134.5	3	3	10	0	0	10	56.4	6	3	3	0	0	0	-90.2	NRQT
100 kHz	20%	2% Rel.	-107	3	3	10	0	0	10	56.4	0	3	3	0	0	0	-56.7	DNBL
1 MHz	20%	2% Rel.	-134.5	3	3	10	0	0	10	56.4	6	3	3	0	0	0	-90.2	NRQT
5 MHz	20%	2% Rel.	-134.5	3	3	10	0	0	10	56.4	6	3	3	0	0	0	-90.2	NRQT
20 MHz	20%	2% Rel.	-134.5	3	3	10	0	0	10	56.4	6	3	3	0	0	0	-90.2	NRQT

BL - Break-lock

RQT-Reacquisition Time

DNBL- Did not break lock at the maximum available UWB generator signal power

NRQT - Broadband Noise Reacquisition

## Operational Scenario: Terrestrial GPS Receiver and Multiple UWB

Device (Indoor Operation)

GPS Receiver Architecture: C/A-code

Broadband Noise			UWB	UWB	UWB	Imax (dBW/MHz)	Hgps (m)	Huwb (m)	Hsep (m)	Theta (deg)	Gr (dBic)	Dmin (m)	Lp (dB)	Lmult (dB)	Lallot (dB)	Lman (dB)	Laf (dB)	Lba (dB)	Lsm (dB)	UWB EIRP (dBW/MHz)	Single Entry GPS Receiver Criteria
PRF	Gating	Mod.	UWB	UWB	UWB	Imax (dBW)	Hgps (m)	Huwb (m)	Hsep (m)	Theta (deg)	Gr (dBic)	Dmin (m)	Lp (dB)	Lmult (dB)	Lallot (dB)	Lman (dB)	Laf (dB)	Lba (dB)	Lsm (dB)	UWB EIRP (dBW)	RQT
1 MHz	100%	None	-134.5	3	10	5	54.5	3	8.6	55.0	0	3	3	0	9	0	-88.7		BL		
5 MHz	100%	None	-145.5	3	10	5	54.5	3	8.6	55.0	0	3	3	0	9	0	-90.5		BL		
20 MHz	100%	None	-145	3	10	5	54.5	3	8.6	55.0	0	3	3	0	9	0	-90.0		BL		
5 MHz	20%	None	-145.2	3	10	5	54.5	3	8.6	55.0	0	3	3	0	9	0	-90.2		BL		
20 MHz	20%	None	-145.8	3	10	5	54.5	3	8.6	55.0	0	3	3	0	9	0	-90.8		BL		
5 MHz	100%	OOK	-144.5	3	10	5	54.5	3	8.6	55.0	0	3	3	0	9	0	-89.5		BL		
20 MHz	100%	OOK	-144.5	3	10	5	54.5	3	8.6	55.0	0	3	3	0	9	0	-89.5		BL		
5 MHz	20%	OOK	-144.2	3	10	5	54.5	3	8.6	55.0	0	3	3	0	9	0	-89.2		BL		
20 MHz	20%	OOK	-146.3	3	10	5	54.5	3	8.6	55.0	0	3	3	0	9	0	-91.3		BL		
UWB	UWB	UWB	Imax (dBW/MHz)	Hgps (m)	Huwb (m)	Hsep (m)	Theta (deg)	Gr (dBic)	Dmin (m)	Lp (dB)	Lmult (dB)	Lallot (dB)	Lman (dB)	Laf (dB)	Lba (dB)	Lsm (dB)	UWB EIRP (dBW/MHz)	Single Entry GPS Receiver Criteria			
PRF	Gating	Mod.	UWB	UWB	UWB	Imax (dBW)	Hgps (m)	Huwb (m)	Hsep (m)	Theta (deg)	Gr (dBic)	Dmin (m)	Lp (dB)	Lmult (dB)	Lallot (dB)	Lman (dB)	Laf (dB)	Lba (dB)	Lsm (dB)	UWB EIRP (dBW)	Single Entry GPS Receiver Criteria
100 kHz	100%	None	-112.6	3	10	5	54.5	3	8.6	55.0	0	3	3	0	9	0	-57.6		BL		
100 kHz	20%	None	-106.5	3	10	5	54.5	3	8.6	55.0	0	3	3	0	9	0	-51.5		DNBL		
1 MHz	20%	None	-134.5	3	10	5	54.5	3	8.6	55.0	6	3	3	0	9	0	-85.5		NRQT		
100 kHz	100%	OOK	-102.6	3	10	5	54.5	3	8.6	55.0	0	3	3	0	9	0	-47.6		DNBL		
1 MHz	100%	OOK	-134.5	3	10	5	54.5	3	8.6	55.0	6	3	3	0	9	0	-85.5		NRQT		
100 kHz	20%	OOK	-109.4	3	10	5	54.5	3	8.6	55.0	0	3	3	0	9	0	-54.4		DNBL		
1 MHz	20%	OOK	-134.5	3	10	5	54.5	3	8.6	55.0	6	3	3	0	9	0	-85.5		NRQT		
100 kHz	100%	50% Abs.	-100	3	10	5	54.5	3	8.6	55.0	6	3	3	0	9	0	-45.0		DNBL		
1 MHz	100%	50% Abs.	-134.5	3	10	5	54.5	3	8.6	55.0	0	3	3	0	9	0	-85.5		NRQT		
5 MHz	100%	50% Abs.	-137	3	10	5	54.5	3	8.6	55.0	6	3	3	0	9	0	-88.0		RQT		
20 MHz	100%	50% Abs.	-138	3	10	5	54.5	3	8.6	55.0	6	3	3	0	9	0	-89.0		RQT		
100 kHz	100%	2% Rel.	-100	3	10	5	54.5	3	8.6	55.0	0	3	3	0	9	0	-45.0		DNBL		
1 MHz	100%	2% Rel.	-134.5	3	10	5	54.5	3	8.6	55.0	6	3	3	0	9	0	-85.5		NRQT		
5 MHz	100%	2% Rel.	-136.5	3	10	5	54.5	3	8.6	55.0	6	3	3	0	9	0	-87.5		RQT		
20 MHz	100%	2% Rel.	-136	3	10	5	54.5	3	8.6	55.0	6	3	3	0	9	0	-87.0		RQT		
100 kHz	20%	50% Abs.	-107	3	10	5	54.5	3	8.6	55.0	0	3	3	0	9	0	-52.0		DNBL		
1 MHz	20%	50% Abs.	-134.5	3	10	5	54.5	3	8.6	55.0	6	3	3	0	9	0	-85.5		NRQT		
5 MHz	20%	50% Abs.	-134.5	3	10	5	54.5	3	8.6	55.0	6	3	3	0	9	0	-85.5		NRQT		
20 MHz	20%	50% Abs.	-134.5	3	10	5	54.5	3	8.6	55.0	6	3	3	0	9	0	-85.5		NRQT		
100 kHz	20%	2% Rel.	-107	3	10	5	54.5	3	8.6	55.0	0	3	3	0	9	0	-52.0		DNBL		
1 MHz	20%	2% Rel.	-134.5	3	10	5	54.5	3	8.6	55.0	6	3	3	0	9	0	-85.5		NRQT		
5 MHz	20%	2% Rel.	-134.5	3	10	5	54.5	3	8.6	55.0	6	3	3	0	9	0	-85.5		NRQT		
20 MHz	20%	2% Rel.	-134.5	3	10	5	54.5	3	8.6	55.0	6	3	3	0	9	0	-85.5		NRQT		

BL - Break-lock

RQT - Reacquisition Time

DNBL - Did not break lock at the maximum available UWB generator signal power

NRQT - Broadband Noise Reacquisition

**Operational Scenario: Navigation in Constricted Waterways GPS Receiver and Multiple UWB Device  
(Indoor Operation) (I)**

**GPS Receiver Architecture: C/A-code**

Broadband Noise			UWB	UWB	UWB	Imax (dBW/MHz)	Hgps (m)	Huwb (m)	Hsep (m)	Theta (deg)	Gr (dBc)	Dmin (m)	Lp (dB)	Lmult (dB)	Lallot (dB)	Lman (dB)	Laf (dB)	Lba (dB)	Lsm (dB)	UWB EIRP (dBW/MHz)	Single Entry GPS Receiver Criteria
PRF	Gatling	Mod.	UWB	UWB	UWB	Imax (dBW)	Hgps (m)	Huwb (m)	Hsep (m)	Theta (deg)	Gr (dBc)	Dmin (m)	Lp (dB)	Lmult (dB)	Lallot (dB)	Lman (dB)	Laf (dB)	Lba (dB)	Lsm (dB)	UWB EIRP (dBW)	RQT
1 MHz	100%	None	-143.7	13.5	10	37.5	-5.3	0	37.7	67.9	6	3	3	0	9	0	-69.6	-72.8	BL		
5 MHz	100%	None	-145.5	13.5	10	37.5	-5.3	0	37.7	67.9	0	3	3	0	9	0	-74.6	-74.6	BL		
20 MHz	100%	None	-145	13.5	10	37.5	-5.3	0	37.7	67.9	0	3	3	0	9	0	-74.1	-74.1	BL		
5 MHz	20%	None	-145.2	13.5	10	37.5	-5.3	0	37.7	67.9	0	3	3	0	9	0	-74.3	-74.3	BL		
20 MHz	20%	None	-145.8	13.5	10	37.5	-5.3	0	37.7	67.9	0	3	3	0	9	0	-74.9	-74.9	BL		
5 MHz	100%	OOK	-144.5	13.5	10	37.5	-5.3	0	37.7	67.9	0	3	3	0	9	0	-73.6	-73.6	BL		
20 MHz	100%	OOK	-144.5	13.5	10	37.5	-5.3	0	37.7	67.9	0	3	3	0	9	0	-73.6	-73.6	BL		
5 MHz	20%	OOK	-144.2	13.5	10	37.5	-5.3	0	37.7	67.9	0	3	3	0	9	0	-73.3	-73.3	BL		
20 MHz	20%	OOK	-146.3	13.5	10	37.5	-5.3	0	37.7	67.9	0	3	3	0	9	0	-75.4	-75.4	BL		
PRF	Gatling	Mod.	UWB	UWB	UWB	Imax (dBW/MHz)	Hgps (m)	Huwb (m)	Hsep (m)	Theta (deg)	Gr (dBc)	Dmin (m)	Lp (dB)	Lmult (dB)	Lallot (dB)	Lman (dB)	Laf (dB)	Lba (dB)	Lsm (dB)	UWB EIRP (dBW/MHz)	GPS Receiver Criteria
100 kHz	100%	None	-112.6	13.5	10	37.5	-5.3	0	37.7	67.9	0	3	3	0	9	0	-41.7	-41.7	BL		
100 kHz	20%	None	-106.5	13.5	10	37.5	-5.3	0	37.7	67.9	0	3	3	0	9	0	-35.6	-35.6	DNBL		
1 MHz	20%	None	-134.5	13.5	10	37.5	-5.3	0	37.7	67.9	6	3	3	0	9	0	-69.6	-69.6	NRQT		
100 kHz	100%	OOK	-102.6	13.5	10	37.5	-5.3	0	37.7	67.9	0	3	3	0	9	0	-31.7	-31.7	DNBL		
1 MHz	100%	OOK	-134.5	13.5	10	37.5	-5.3	0	37.7	67.9	6	3	3	0	9	0	-69.6	-69.6	NRQT		
100 kHz	20%	OOK	-109.4	13.5	10	37.5	-5.3	0	37.7	67.9	0	3	3	0	9	0	-38.5	-38.5	DNBL		
1 MHz	20%	OOK	-134.5	13.5	10	37.5	-5.3	0	37.7	67.9	6	3	3	0	9	0	-69.6	-69.6	NRQT		
100 kHz	100%	50% Abs.	-100	13.5	10	37.5	-5.3	0	37.7	67.9	0	3	3	0	9	0	-29.1	-29.1	DNBL		
1 MHz	100%	50% Abs.	-134.5	13.5	10	37.5	-5.3	0	37.7	67.9	6	3	3	0	9	0	-69.6	-69.6	NRQT		
5 MHz	100%	50% Abs.	-137	13.5	10	37.5	-5.3	0	37.7	67.9	6	3	3	0	9	0	-72.1	-72.1	RQT		
20 MHz	100%	50% Abs.	-138	13.5	10	37.5	-5.3	0	37.7	67.9	6	3	3	0	9	0	-73.1	-73.1	RQT		
100 kHz	100%	2% Rel.	-100	13.5	10	37.5	-5.3	0	37.7	67.9	0	3	3	0	9	0	-29.1	-29.1	DNBL		
1 MHz	100%	2% Rel.	-134.5	13.5	10	37.5	-5.3	0	37.7	67.9	6	3	3	0	9	0	-69.6	-69.6	NRQT		
5 MHz	100%	2% Rel.	-136.5	13.5	10	37.5	-5.3	0	37.7	67.9	6	3	3	0	9	0	-71.6	-71.6	RQT		
20 MHz	100%	2% Rel.	-136	13.5	10	37.5	-5.3	0	37.7	67.9	6	3	3	0	9	0	-71.1	-71.1	RQT		
100 kHz	20%	50% Abs.	-107	13.5	10	37.5	-5.3	0	37.7	67.9	0	3	3	0	9	0	-36.1	-36.1	DNBL		
1 MHz	20%	50% Abs.	-134.5	13.5	10	37.5	-5.3	0	37.7	67.9	6	3	3	0	9	0	-69.6	-69.6	NRQT		
5 MHz	20%	50% Abs.	-134.5	13.5	10	37.5	-5.3	0	37.7	67.9	6	3	3	0	9	0	-69.6	-69.6	NRQT		
20 MHz	20%	50% Abs.	-134.5	13.5	10	37.5	-5.3	0	37.7	67.9	6	3	3	0	9	0	-69.6	-69.6	NRQT		
100 kHz	20%	2% Rel.	-107	13.5	10	37.5	-5.3	0	37.7	67.9	0	3	3	0	9	0	-36.1	-36.1	DNBL		
1 MHz	20%	2% Rel.	-134.5	13.5	10	37.5	-5.3	0	37.7	67.9	6	3	3	0	9	0	-69.6	-69.6	NRQT		
5 MHz	20%	2% Rel.	-134.5	13.5	10	37.5	-5.3	0	37.7	67.9	6	3	3	0	9	0	-69.6	-69.6	NRQT		
20 MHz	20%	2% Rel.	-134.5	13.5	10	37.5	-5.3	0	37.7	67.9	6	3	3	0	9	0	-69.6	-69.6	NRQT		

BL -Break-lock

RQT - Reacquisition Time

DNBL - Did not break lock at the maximum available UWB generator signal power

NRQT - Broadband Noise Reacquisition

## B-6

### Operational Scenario: Navigation in Constricted Waterways GPS Receiver and Multiple UWB Device (Outdoor Operation) (I)

#### GPS Receiver Architecture: C/A-code

Broadband Noise															GPS Receiver Criteria			
UWB PRF	UWB Gatling	UWB Mod.	I <sub>max</sub> (dBW/MHz)	H <sub>gps</sub> (m)	H <sub>uwB</sub> (m)	H <sub>sep</sub> (m)	Theta (deg)	G <sub>r</sub> (dBic)	D <sub>min</sub> (m)	L <sub>p</sub> (dB)	L <sub>mult</sub> (dB)	L <sub>allot</sub> (dB)	L <sub>man</sub> (dB)	L <sub>aF</sub> (dB)	L <sub>bA</sub> (dB)	L <sub>sM</sub> (dB)	UWB EIRP (dBW/MHz)	RQT
1 MHz	100%	None	-134.5	13.5	3	37.5	-15.6	-3	38.9	68.2	6	3	3	0	0	0	-75.3	UWB EIRP (dBW)
5 MHz	100%	None	-143.7	13.5	3	37.5	-15.6	-3	38.9	68.2	0	3	3	0	0	0	-78.5	BL
20 MHz	100%	None	-145.5	13.5	3	37.5	-15.6	-3	38.9	68.2	0	3	3	0	0	0	-80.3	BL
5 MHz	20%	None	-145	13.5	3	37.5	-15.6	-3	38.9	68.2	0	3	3	0	0	0	-79.8	BL
20 MHz	20%	None	-145.2	13.5	3	37.5	-15.6	-3	38.9	68.2	0	3	3	0	0	0	-80.0	BL
5 MHz	100%	OOK	-145.8	13.5	3	37.5	-15.6	-3	38.9	68.2	0	3	3	0	0	0	-80.6	BL
20 MHz	100%	OOK	-144.5	13.5	3	37.5	-15.6	-3	38.9	68.2	0	3	3	0	0	0	-79.3	BL
5 MHz	20%	OOK	-144.5	13.5	3	37.5	-15.6	-3	38.9	68.2	0	3	3	0	0	0	-79.3	BL
20 MHz	20%	OOK	-144.2	13.5	3	37.5	-15.6	-3	38.9	68.2	0	3	3	0	0	0	-79.0	BL
20 MHz	20%	OOK	-146.3	13.5	3	37.5	-15.6	-3	38.9	68.2	0	3	3	0	0	0	-81.1	BL
UWB PRF	UWB Gatling	UWB Mod.	I <sub>max</sub> (dBW/MHz)	H <sub>gps</sub> (m)	H <sub>uwB</sub> (m)	H <sub>sep</sub> (m)	Theta (deg)	G <sub>r</sub> (dBic)	D <sub>min</sub> (m)	L <sub>p</sub> (dB)	L <sub>mult</sub> (dB)	L <sub>allot</sub> (dB)	L <sub>man</sub> (dB)	L <sub>aF</sub> (dB)	L <sub>bA</sub> (dB)	L <sub>sM</sub> (dB)	UWB EIRP (dBW/MHz)	GPS Receiver Criteria
100 kHz	100%	None	-112.6	13.5	3	37.5	-15.6	-3	38.9	68.2	0	3	3	0	0	0	-47.4	BL
100 kHz	20%	None	-106.5	13.5	3	37.5	-15.6	-3	38.9	68.2	0	3	3	0	0	0	-41.3	DNBL
1 MHz	20%	None	-134.5	13.5	3	37.5	-15.6	-3	38.9	68.2	6	3	3	0	0	0	-75.3	NRQT
100 kHz	100%	OOK	-102.6	13.5	3	37.5	-15.6	-3	38.9	68.2	0	3	3	0	0	0	-37.4	DNBL
1 MHz	100%	OOK	-134.5	13.5	3	37.5	-15.6	-3	38.9	68.2	6	3	3	0	0	0	-75.3	NRQT
100 kHz	20%	OOK	-109.4	13.5	3	37.5	-15.6	-3	38.9	68.2	0	3	3	0	0	0	-44.2	DNBL
1 MHz	20%	OOK	-134.5	13.5	3	37.5	-15.6	-3	38.9	68.2	6	3	3	0	0	0	-75.3	NRQT
100 kHz	100%	50% Abs.	-100	13.5	3	37.5	-15.6	-3	38.9	68.2	0	3	3	0	0	0	-34.8	DNBL
1 MHz	100%	50% Abs.	-134.5	13.5	3	37.5	-15.6	-3	38.9	68.2	6	3	3	0	0	0	-75.3	NRQT
5 MHz	100%	50% Abs.	-137	13.5	3	37.5	-15.6	-3	38.9	68.2	6	3	3	0	0	0	-77.8	RQT
20 MHz	100%	50% Abs.	-138	13.5	3	37.5	-15.6	-3	38.9	68.2	6	3	3	0	0	0	-78.8	RQT
100 kHz	100%	2% Rel.	-100	13.5	3	37.5	-15.6	-3	38.9	68.2	0	3	3	0	0	0	-34.8	DNBL
1 MHz	100%	2% Rel.	-134.5	13.5	3	37.5	-15.6	-3	38.9	68.2	6	3	3	0	0	0	-75.3	NRQT
5 MHz	100%	2% Rel.	-136.5	13.5	3	37.5	-15.6	-3	38.9	68.2	6	3	3	0	0	0	-77.3	RQT
20 MHz	100%	2% Rel.	-136	13.5	3	37.5	-15.6	-3	38.9	68.2	6	3	3	0	0	0	-76.8	RQT
100 kHz	20%	50% Abs.	-107	13.5	3	37.5	-15.6	-3	38.9	68.2	6	3	3	0	0	0	-41.8	DNBL
1 MHz	20%	50% Abs.	-13.5	13.5	3	37.5	-15.6	-3	38.9	68.2	6	3	3	0	0	0	-75.3	NRQT
5 MHz	20%	50% Abs.	-134.5	13.5	3	37.5	-15.6	-3	38.9	68.2	6	3	3	0	0	0	-75.3	NRQT
20 MHz	20%	50% Abs.	-134.5	13.5	3	37.5	-15.6	-3	38.9	68.2	6	3	3	0	0	0	-75.3	NRQT
100 kHz	20%	2% Rel.	-107	13.5	3	37.5	-15.6	-3	38.9	68.2	0	3	3	0	0	0	-41.8	DNBL
1 MHz	20%	2% Rel.	-134.5	13.5	3	37.5	-15.6	-3	38.9	68.2	6	3	3	0	0	0	-75.3	NRQT
5 MHz	20%	2% Rel.	-134.5	13.5	3	37.5	-15.6	-3	38.9	68.2	6	3	3	0	0	0	-75.3	NRQT
20 MHz	20%	2% Rel.	-134.5	13.5	3	37.5	-15.6	-3	38.9	68.2	6	3	3	0	0	0	-75.3	NRQT

BL - Break-lock

RQT - Reacquisition Time

DNBL - Did not break lock at the maximum UWB generator signal power

NRQT - Broadband Noise Reacquisition

**Operational Scenario: Navigation in Constricted Waterways GPS Receiver and Multiple UWB Device  
(Indoor Operation) (II)**

**GPS Receiver Architecture: C/A-code**

Broadband Noise																		GPS Receiver Criteria
UWB	UWB	UWB	Imax (dBW)	Hgps (m)	Huwb (m)	Hsep (m)	Theta (deg)	Gr (dBiC)	Dmin (m)	Lp (dB)	Lmult (dB)	Lallot (dB)	Lman (dB)	Laf (dB)	Lba (dB)	Lsm (dB)	UWB EIRP (dBW/MHz)	
1 MHz	100%	None	-134.5	7.5	10	51	2.8	0	51.1	70.5	6	3	3	0	9	0	-67.0	RQT
5 MHz	100%	None	-143.7	7.5	10	51	2.8	0	51.1	70.5	0	3	3	0	9	0	-70.2	BL
20 MHz	100%	None	-145.5	7.5	10	51	2.8	0	51.1	70.5	0	3	3	0	9	0	-72.0	BL
5 MHz	20%	None	-145.2	7.5	10	51	2.8	0	51.1	70.5	0	3	3	0	9	0	-71.5	BL
20 MHz	20%	None	-145.8	7.5	10	51	2.8	0	51.1	70.5	0	3	3	0	9	0	-72.3	BL
5 MHz	100%	OOK	-144.5	7.5	10	51	2.8	0	51.1	70.5	0	3	3	0	9	0	-71.0	BL
20 MHz	100%	OOK	-144.5	7.5	10	51	2.8	0	51.1	70.5	0	3	3	0	9	0	-71.0	BL
5 MHz	20%	OOK	-144.2	7.5	10	51	2.8	0	51.1	70.5	0	3	3	0	9	0	-70.7	BL
20 MHz	20%	OOK	-146.3	7.5	10	51	2.8	0	51.1	70.5	0	3	3	0	9	0	-72.8	BL
UWB	UWB	UWB	Imax (dBW/MHz)	Hgps (m)	Huwb (m)	Hsep (m)	Theta (deg)	Gr (dBiC)	Dmin (m)	Lp (dB)	Lmult (dB)	Lallot (dB)	Lman (dB)	Laf (dB)	Lba (dB)	Lsm (dB)	UWB EIRP (dBW/MHz)	GPS Receiver Criteria
100 kHz	100%	None	-112.6	7.5	10	51	2.8	0	51.1	70.5	0	3	3	0	9	0	-39.1	BL
100 kHz	20%	None	-106.5	7.5	10	51	2.8	0	51.1	70.5	0	3	3	0	9	0	-33.0	DNBL
1 MHz	20%	None	-134.5	7.5	10	51	2.8	0	51.1	70.5	6	3	3	0	9	0	-67.0	NRQT
100 kHz	100%	OOK	-102.6	7.5	10	51	2.8	0	51.1	70.5	0	3	3	0	9	0	-29.1	DNBL
1 MHz	100%	OOK	-134.5	7.5	10	51	2.8	0	51.1	70.5	6	3	3	0	9	0	-67.0	NRQT
100 kHz	20%	OOK	-109.4	7.5	10	51	2.8	0	51.1	70.5	0	3	3	0	9	0	-35.9	DNBL
1 MHz	20%	OOK	-134.5	7.5	10	51	2.8	0	51.1	70.5	6	3	3	0	9	0	-67.0	NRQT
100 kHz	100%	50% Abs.	-100	7.5	10	51	2.8	0	51.1	70.5	0	3	3	0	9	0	-26.5	DNBL
1 MHz	100%	50% Abs.	-134.5	7.5	10	51	2.8	0	51.1	70.5	6	3	3	0	9	0	-67.0	NRQT
5 MHz	100%	50% Abs.	-137	7.5	10	51	2.8	0	51.1	70.5	6	3	3	0	9	0	-69.5	RQT
20 MHz	100%	50% Abs.	-138	7.5	10	51	2.8	0	51.1	70.5	6	3	3	0	9	0	-70.5	RQT
100 kHz	100%	2% Rel.	-100	7.5	10	51	2.8	0	51.1	70.5	0	3	3	0	9	0	-26.5	DNBL
1 MHz	100%	2% Rel.	-134.5	7.5	10	51	2.8	0	51.1	70.5	6	3	3	0	9	0	-67.0	NRQT
5 MHz	100%	2% Rel.	-136.5	7.5	10	51	2.8	0	51.1	70.5	6	3	3	0	9	0	-69.0	RQT
20 MHz	100%	2% Rel.	-136	7.5	10	51	2.8	0	51.1	70.5	6	3	3	0	9	0	-68.5	RQT
100 kHz	20%	50% Abs.	-107	7.5	10	51	2.8	0	51.1	70.5	0	3	3	0	9	0	-33.5	DNBL
1 MHz	20%	50% Abs.	-134.5	7.5	10	51	2.8	0	51.1	70.5	6	3	3	0	9	0	-67.0	NRQT
5 MHz	20%	50% Abs.	-134.5	7.5	10	51	2.8	0	51.1	70.5	6	3	3	0	9	0	-67.0	NRQT
20 MHz	20%	50% Abs.	-134.5	7.5	10	51	2.8	0	51.1	70.5	6	3	3	0	9	0	-67.0	NRQT
100 kHz	20%	2% Rel.	-107	7.5	10	51	2.8	0	51.1	70.5	0	3	3	0	9	0	-33.5	DNBL
1 MHz	20%	2% Rel.	-134.5	7.5	10	51	2.8	0	51.1	70.5	6	3	3	0	9	0	-67.0	NRQT
5 MHz	20%	2% Rel.	-134.5	7.5	10	51	2.8	0	51.1	70.5	6	3	3	0	9	0	-67.0	NRQT
20 MHz	20%	2% Rel.	-134.5	7.5	10	51	2.8	0	51.1	70.5	6	3	3	0	9	0	-67.0	NRQT

BL - Break-lock

RQT - Reacquisition Time

DNBL - Did not break lock at the maximum available UWB generator signal power

NRQT - Broadband Noise Reacquisition

## Operational Scenario: Navigation In Constricted Waterways GPS Receiver and Multiple UWB Device (Outdoor Operation) (II)

## GPS Receiver Architecture: C/A-code

															GPS Receiver Criteria			
Broadband Noise			I <sub>max</sub> (dBW/MHz)	H <sub>gps</sub> (m)	H <sub>uw</sub> (m)	H <sub>sep</sub> (m)	Theta (deg)	G <sub>r</sub> (dBiC)	D <sub>min</sub> (m)	L <sub>p</sub> (dB)	L <sub>mult</sub> (dB)	L <sub>allot</sub> (dB)	L <sub>man</sub> (dB)	L <sub>aF</sub> (dB)	L <sub>bA</sub> (dB)	L <sub>sM</sub> (dB)	UWB EIRP (dBW/MHz)	
UWB	UWB	UWB	I <sub>max</sub> (dBW)	H <sub>gps</sub> (m)	H <sub>uw</sub> (m)	H <sub>sep</sub> (m)	Theta (deg)	G <sub>r</sub> (dBiC)	D <sub>min</sub> (m)	L <sub>p</sub> (dB)	L <sub>mult</sub> (dB)	L <sub>allot</sub> (dB)	L <sub>man</sub> (dB)	L <sub>aF</sub> (dB)	L <sub>bA</sub> (dB)	L <sub>sM</sub> (dB)	UWB EIRP (dBW)	RQT
1 MHz	100%	None	-134.5	7.5	3	51	-5.0	0	51.2	70.5	6	3	3	0	0	0	-76.0	BL
5 MHz	100%	None	-143.7	7.5	3	51	-5.0	0	51.2	70.5	0	3	3	0	0	0	-79.2	BL
20 MHz	100%	None	-145.5	7.5	3	51	-5.0	0	51.2	70.5	0	3	3	0	0	0	-81.0	BL
5 MHz	20%	None	-145	7.5	3	51	-5.0	0	51.2	70.5	0	3	3	0	0	0	-80.5	BL
20 MHz	20%	None	-145.2	7.5	3	51	-5.0	0	51.2	70.5	0	3	3	0	0	0	-80.7	BL
5 MHz	100%	OOK	-145.8	7.5	3	51	-5.0	0	51.2	70.5	0	3	3	0	0	0	-81.3	BL
20 MHz	100%	OOK	-144.5	7.5	3	51	-5.0	0	51.2	70.5	0	3	3	0	0	0	-80.0	BL
5 MHz	20%	OOK	-144.5	7.5	3	51	-5.0	0	51.2	70.5	0	3	3	0	0	0	-80.0	BL
20 MHz	20%	OOK	-144.2	7.5	3	51	-5.0	0	51.2	70.5	0	3	3	0	0	0	-79.7	BL
			-146.3	7.5	3	51	-5.0	0	51.2	70.5	0	3	3	0	0	0	-81.8	BL
UWB	UWB	UWB	I <sub>max</sub> (dBW/MHz)	H <sub>gps</sub> (m)	H <sub>uw</sub> (m)	H <sub>sep</sub> (m)	Theta (deg)	G <sub>r</sub> (dBiC)	D <sub>min</sub> (m)	L <sub>p</sub> (dB)	L <sub>mult</sub> (dB)	L <sub>allot</sub> (dB)	L <sub>man</sub> (dB)	L <sub>aF</sub> (dB)	L <sub>bA</sub> (dB)	L <sub>sM</sub> (dB)	UWB EIRP (dBW/MHz)	GPS Receiver Criteria
PRF	Gating	Mod.	I <sub>max</sub> (dBW)	H <sub>gps</sub> (m)	H <sub>uw</sub> (m)	H <sub>sep</sub> (m)	Theta (deg)	G <sub>r</sub> (dBiC)	D <sub>min</sub> (m)	L <sub>p</sub> (dB)	L <sub>mult</sub> (dB)	L <sub>allot</sub> (dB)	L <sub>man</sub> (dB)	L <sub>aF</sub> (dB)	L <sub>bA</sub> (dB)	L <sub>sM</sub> (dB)	UWB EIRP (dBW)	
100 kHz	100%	None	-112.6	7.5	3	51	-5.0	0	51.2	70.5	0	3	3	0	0	0	-48.1	BL
100 kHz	20%	None	-106.5	7.5	3	51	-5.0	0	51.2	70.5	0	3	3	0	0	0	-42.0	DNBL
1 MHz	20%	None	-134.5	7.5	3	51	-5.0	0	51.2	70.5	6	3	3	0	0	0	-76.0	NRQT
100 kHz	100%	OOK	-102.6	7.5	3	51	-5.0	0	51.2	70.5	0	3	3	0	0	0	-38.1	DNBL
1 MHz	100%	OOK	-134.5	7.5	3	51	-5.0	0	51.2	70.5	6	3	3	0	0	0	-76.0	NRQT
100 kHz	20%	OOK	-109.4	7.5	3	51	-5.0	0	51.2	70.5	0	3	3	0	0	0	-44.9	DNBL
1 MHz	20%	OOK	-134.5	7.5	3	51	-5.0	0	51.2	70.5	6	3	3	0	0	0	-76.0	NRQT
100 kHz	100%	50% Abs.	-100	7.5	3	51	-5.0	0	51.2	70.5	0	3	3	0	0	0	-35.5	DNBL
1 MHz	100%	50% Abs.	-134.5	7.5	3	51	-5.0	0	51.2	70.5	6	3	3	0	0	0	-76.0	NRQT
5 MHz	100%	50% Abs.	-137	7.5	3	51	-5.0	0	51.2	70.5	6	3	3	0	0	0	-78.5	RQT
20 MHz	100%	50% Abs.	-138	7.5	3	51	-5.0	0	51.2	70.5	6	3	3	0	0	0	-79.5	RQT
100 kHz	100%	2% Rel.	-100	7.5	3	51	-5.0	0	51.2	70.5	0	3	3	0	0	0	-35.5	DNBL
1 MHz	100%	2% Rel.	-134.5	7.5	3	51	-5.0	0	51.2	70.5	6	3	3	0	0	0	-76.0	NRQT
5 MHz	100%	2% Rel.	-136.5	7.5	3	51	-5.0	0	51.2	70.5	6	3	3	0	0	0	-78.0	RQT
20 MHz	100%	2% Rel.	-136	7.5	3	51	-5.0	0	51.2	70.5	6	3	3	0	0	0	-77.5	RQT
100 kHz	20%	50% Abs.	-107	7.5	3	51	-5.0	0	51.2	70.5	0	3	3	0	0	0	-42.5	DNBL
1 MHz	20%	50% Abs.	-134.5	7.5	3	51	-5.0	0	51.2	70.5	6	3	3	0	0	0	-76.0	NRQT
5 MHz	20%	50% Abs.	-134.5	7.5	3	51	-5.0	0	51.2	70.5	6	3	3	0	0	0	-76.0	NRQT
20 MHz	20%	50% Abs.	-134.5	7.5	3	51	-5.0	0	51.2	70.5	6	3	3	0	0	0	-76.0	NRQT
100 kHz	20%	2% Rel.	-107	7.5	3	51	-5.0	0	51.2	70.5	0	3	3	0	0	0	-42.5	DNBL
1 MHz	20%	2% Rel.	-134.5	7.5	3	51	-5.0	0	51.2	70.5	6	3	3	0	0	0	-76.0	NRQT
5 MHz	20%	2% Rel.	-134.5	7.5	3	51	-5.0	0	51.2	70.5	6	3	3	0	0	0	-76.0	NRQT
20 MHz	20%	2% Rel.	-134.5	7.5	3	51	-5.0	0	51.2	70.5	6	3	3	0	0	0	-76.0	NRQT

BL - Break-lock

RQT - Reacquisition Time

DNBL - Did not break lock at the maximum

UWB generator signal power

NRQT - Broadband Noise Reacquisition

**Operational Scenario: Railway GPS Receiver and Multiple UWB Device (Outdoor Operation)**

**GPS Receiver Architecture: C/A-code**

Operational Scenario: Railway GPS Receiver and Multiple UWB Device (Outdoor Operation) - GPS Receiver Architecture: C/A-code																GPS Receiver Criteria			
Broadband Noise		UWB	UWB	UWB	Imax (dBW/MHz)	Hgps (m)	Huwb (m)	Hsep (m)	Theta (deg)	Gr (dBic)	Dmin (m)	Lp (dB)	Lmult (dB)	Lallot (dB)	Lman (dB)	Laf (dB)	Lba (dB)	Lsm (dB)	UWB EIRP (dBW/MHz)
PRF	Gating	Mod.	Imax (dBW)	Hgps (m)	Huwb (m)	Hsep (m)	Theta (deg)	Gr (dBic)	Dmin (m)	Lp (dB)	Lmult (dB)	Lallot (dB)	Lman (dB)	Laf (dB)	Lba (dB)	Lsm (dB)	UWB EIRP (dBW)	RQT	
1 MHz	100%	None	-134.5	10	3	7	-45	-4.5	9.9	56.3	4.8	3	3	0	0	0	-84.5	UWB EIRP	
5 MHz	100%	None	-143.7	10	3	7	-45	-4.5	9.9	56.3	0	3	3	0	0	0	-88.9	BL	
20 MHz	100%	None	-145.5	10	3	7	-45	-4.5	9.9	56.3	0	3	3	0	0	0	-90.7	BL	
5 MHz	20%	None	-145	10	3	7	-45	-4.5	9.9	56.3	0	3	3	0	0	0	-90.2	BL	
20 MHz	20%	None	-145.2	10	3	7	-45	-4.5	9.9	56.3	0	3	3	0	0	0	-90.4	BL	
5 MHz	100%	OOK	-145.8	10	3	7	-45	-4.5	9.9	56.3	0	3	3	0	0	0	-91.0	BL	
20 MHz	100%	OOK	-144.5	10	3	7	-45	-4.5	9.9	56.3	0	3	3	0	0	0	-89.7	BL	
5 MHz	20%	OOK	-144.5	10	3	7	-45	-4.5	9.9	56.3	0	3	3	0	0	0	-89.7	BL	
20 MHz	20%	OOK	-144.2	10	3	7	-45	-4.5	9.9	56.3	0	3	3	0	0	0	-89.4	BL	
100 kHz	100%	None	-146.3	10	3	7	-45	-4.5	9.9	56.3	0	3	3	0	0	0	-91.5	BL	
GPS Receiver Criteria																			
100 kHz	20%	None	-112.6	10	3	7	-45	-4.5	9.9	56.3	0	3	3	0	0	0	-57.8	BL	
100 kHz	20%	None	-106.5	10	3	7	-45	-4.5	9.9	56.3	0	3	3	0	0	0	-51.7	DNBL	
1 MHz	20%	None	-134.5	10	3	7	-45	-4.5	9.9	56.3	4.8	3	3	0	0	0	-84.5	NRQT	
100 kHz	100%	OOK	-102.6	10	3	7	-45	-4.5	9.9	56.3	0	3	3	0	0	0	-47.8	DNBL	
1 MHz	100%	OOK	-134.5	10	3	7	-45	-4.5	9.9	56.3	4.8	3	3	0	0	0	-84.5	NRQT	
100 kHz	20%	OOK	-109.4	10	3	7	-45	-4.5	9.9	56.3	0	3	3	0	0	0	-54.6	DNBL	
1 MHz	20%	OOK	-134.5	10	3	7	-45	-4.5	9.9	56.3	4.8	3	3	0	0	0	-84.5	NRQT	
100 kHz	100%	50% Abs.	-100	10	3	7	-45	-4.5	9.9	56.3	0	3	3	0	0	0	-45.2	DNBL	
1 MHz	100%	50% Abs.	-134.5	10	3	7	-45	-4.5	9.9	56.3	4.8	3	3	0	0	0	-84.5	NRQT	
5 MHz	100%	50% Abs.	-137	10	3	7	-45	-4.5	9.9	56.3	4.8	3	3	0	0	0	-87	RQT	
20 MHz	100%	50% Abs.	-138	10	3	7	-45	-4.5	9.9	56.3	4.8	3	3	0	0	0	-88	RQT	
100 kHz	100%	2% Rel.	-100	10	3	7	-45	-4.5	9.9	56.3	0	3	3	0	0	0	-45.2	DNBL	
1 MHz	100%	2% Rel.	-134.5	10	3	7	-45	-4.5	9.9	56.3	4.8	3	3	0	0	0	-84.5	NRQT	
5 MHz	100%	2% Rel.	-136.5	10	3	7	-45	-4.5	9.9	56.3	4.8	3	3	0	0	0	-86.5	RQT	
20 MHz	100%	2% Rel.	-136	10	3	7	-45	-4.5	9.9	56.3	4.8	3	3	0	0	0	-86	RQT	
100 kHz	20%	50% Abs.	-107	10	3	7	-45	-4.5	9.9	56.3	0	3	3	0	0	0	-52.2	DNBL	
1 MHz	20%	50% Abs.	-134.5	10	3	7	-45	-4.5	9.9	56.3	4.8	3	3	0	0	0	-84.5	NRQT	
5 MHz	20%	50% Abs.	-134.5	10	3	7	-45	-4.5	9.9	56.3	4.8	3	3	0	0	0	-84.5	NRQT	
20 MHz	20%	50% Abs.	-134.5	10	3	7	-45	-4.5	9.9	56.3	4.8	3	3	0	0	0	-84.5	NRQT	
100 kHz	20%	2% Rel.	-107	10	3	7	-45	-4.5	9.9	56.3	0	3	3	0	0	0	-52.2	DNBL	
1 MHz	20%	2% Rel.	-134.5	10	3	7	-45	-4.5	9.9	56.3	4.8	3	3	0	0	0	-84.5	NRQT	
5 MHz	20%	2% Rel.	-134.5	10	3	7	-45	-4.5	9.9	56.3	4.8	3	3	0	0	0	-84.5	NRQT	
20 MHz	20%	2% Rel.	-134.5	10	3	7	-45	-4.5	9.9	56.3	4.8	3	3	0	0	0	-84.5	NRQT	

BL - Break-lock

RQT - Reacquisition Time

DNBL - Did not break lock at the maximum UWB generator signal power

NRQT - Broadband Noise Reacquisition

**Operational Scenario: Railway GPS Receiver and Multiple UWB Device  
(Indoor Operation)**

**GPS Receiver Architecture: C/A-code**

Broadband Noise			I <sub>max</sub> (dBW/MHz)	H <sub>gps</sub> (m)	H <sub>uwb</sub> (m)	H <sub>sep</sub> (m)	Theta (deg)	G <sub>r</sub> (dBic)	D <sub>min</sub> (m)	L <sub>p</sub> (dB)	L <sub>mult</sub> (dB)	L <sub>allot</sub> (dB)	L <sub>man</sub> (dB)	L <sub>aaf</sub> (dB)	L <sub>ba</sub> (dB)	L <sub>sm</sub> (dB)	UWB EIRP (dBW/MHz)	GPS Receiver Criteria
UWB PRF	UWB Gating	UWB Mod.	I <sub>max</sub> (dBW)	H <sub>gps</sub> (m)	H <sub>uwb</sub> (m)	H <sub>sep</sub> (m)	Theta (deg)	G <sub>r</sub> (dBic)	D <sub>min</sub> (m)	L <sub>p</sub> (dB)	L <sub>mult</sub> (dB)	L <sub>allot</sub> (dB)	L <sub>man</sub> (dB)	L <sub>aaf</sub> (dB)	L <sub>ba</sub> (dB)	L <sub>sm</sub> (dB)	UWB EIRP (dBW)	RQT
1 MHz	100%	None	-143.7	10	10	7	0.0	0	7.0	53.3	4.8	3	3	0	9	0	-87.4	BL
5 MHz	100%	None	-145.5	10	10	7	0.0	0	7.0	53.3	0	3	3	0	9	0	-89.2	BL
20 MHz	100%	None	-145	10	10	7	0.0	0	7.0	53.3	0	3	3	0	9	0	-88.7	BL
5 MHz	20%	None	-145.2	10	10	7	0.0	0	7.0	53.3	0	3	3	0	9	0	-88.9	BL
20 MHz	20%	None	-145.8	10	10	7	0.0	0	7.0	53.3	0	3	3	0	9	0	-89.5	BL
5 MHz	100%	OOK	-144.5	10	10	7	0.0	0	7.0	53.3	0	3	3	0	9	0	-88.2	BL
20 MHz	100%	OOK	-144.5	10	10	7	0.0	0	7.0	53.3	0	3	3	0	9	0	-87.9	BL
5 MHz	20%	OOK	-144.2	10	10	7	0.0	0	7.0	53.3	0	3	3	0	9	0	-90.0	BL
UWB PRF	UWB Gating	UWB Mod.	I <sub>max</sub> (dBW/MHz)	H <sub>gps</sub> (m)	H <sub>uwb</sub> (m)	H <sub>sep</sub> (m)	Theta (deg)	G <sub>r</sub> (dBic)	D <sub>min</sub> (m)	L <sub>p</sub> (dB)	L <sub>mult</sub> (dB)	L <sub>allot</sub> (dB)	L <sub>man</sub> (dB)	L <sub>aaf</sub> (dB)	L <sub>ba</sub> (dB)	L <sub>sm</sub> (dB)	UWB EIRP (dBW/MHz)	GPS Receiver Criteria
100 kHz	100%	None	-112.6	10	10	7	0.0	0	7.0	53.3	0	3	3	0	9	0	-56.3	BL
100 kHz	20%	None	-106.5	10	10	7	0.0	0	7.0	53.3	0	3	3	0	9	0	-50.2	DNBL
1 MHz	20%	None	-134.5	10	10	7	0.0	0	7.0	53.3	4.8	3	3	0	9	0	-83	NRQT
100 kHz	100%	OOK	-102.6	10	10	7	0.0	0	7.0	53.3	0	3	3	0	9	0	-46.3	DNBL
1 MHz	100%	OOK	-134.5	10	10	7	0.0	0	7.0	53.3	4.8	3	3	0	9	0	-83	NRQT
100 kHz	20%	OOK	-109.4	10	10	7	0.0	0	7.0	53.3	0	3	3	0	9	0	-53.1	DNBL
1 MHz	20%	OOK	-134.5	10	10	7	0.0	0	7.0	53.3	4.8	3	3	0	9	0	-83	NRQT
100 kHz	100%	50% Abs.	-100	10	10	7	0.0	0	7.0	53.3	0	3	3	0	9	0	-43.7	DNBL
1 MHz	100%	50% Abs.	-134.5	10	10	7	0.0	0	7.0	53.3	4.8	3	3	0	9	0	-83	NRQT
5 MHz	100%	50% Abs.	-137	10	10	7	0.0	0	7.0	53.3	4.8	3	3	0	9	0	-85.5	RQT
20 MHz	100%	50% Abs.	-138	10	10	7	0.0	0	7.0	53.3	4.8	3	3	0	9	0	-86.5	RQT
100 kHz	100%	2% Rel.	-100	10	10	7	0.0	0	7.0	53.3	4.8	3	3	0	9	0	-43.7	DNBL
1 MHz	100%	2% Rel.	-134.5	10	10	7	0.0	0	7.0	53.3	4.8	3	3	0	9	0	-83	NRQT
5 MHz	100%	2% Rel.	-136.5	10	10	7	0.0	0	7.0	53.3	4.8	3	3	0	9	0	-85	RQT
20 MHz	100%	2% Rel.	-136	10	10	7	0.0	0	7.0	53.3	4.8	3	3	0	9	0	-84.5	RQT
100 kHz	20%	50% Abs.	-107	10	10	7	0.0	0	7.0	53.3	0	3	3	0	9	0	-50.7	DNBL
1 MHz	20%	50% Abs.	-134.5	10	10	7	0.0	0	7.0	53.3	4.8	3	3	0	9	0	-83	NRQT
5 MHz	20%	50% Abs.	-134.5	10	10	7	0.0	0	7.0	53.3	4.8	3	3	0	9	0	-83	NRQT
20 MHz	20%	50% Abs.	-134.5	10	10	7	0.0	0	7.0	53.3	4.8	3	3	0	9	0	-83	NRQT
100 kHz	20%	2% Rel.	-107	10	10	7	0.0	0	7.0	53.3	0	3	3	0	9	0	-50.7	DNBL
1 MHz	20%	2% Rel.	-134.5	10	10	7	0.0	0	7.0	53.3	4.8	3	3	0	9	0	-83	NRQT
5 MHz	20%	2% Rel.	-134.5	10	10	7	0.0	0	7.0	53.3	4.8	3	3	0	9	0	-83	NRQT
20 MHz	20%	2% Rel.	-134.5	10	10	7	0.0	0	7.0	53.3	4.8	3	3	0	9	0	-83	NRQT

BL - Break-lock

RQT - Reacquisition Time

DNBL - Did not break lock at the maximum UWB generator signal power

NRQT - Broadband Noise Reacquisition

**Operational Scenario: Surveying GPS Receiver and Single UWB Device**

**GPS Receiver Architecture: Semi-Codeless**

Broadband Noise		UWB	UWB	UWB	I <sub>max</sub> (dBW/ MHz)	H <sub>gps</sub> (m)	H <sub>ubw</sub> (m)	H <sub>sep</sub> (m)	Theta (deg)	G <sub>r</sub> (dBc)	D <sub>min</sub> (m)	L <sub>p</sub> (dB)	L <sub>mult</sub> (dB)	L <sub>allot</sub> (dB)	L <sub>man</sub> (dB)	L <sub>a</sub> (dB)	L <sub>b</sub> (dB)	L <sub>s</sub> (dB)	UWB EIRP (dBW/MHz)	GPS Receiver Criteria
PRF	Gating	Mod.		I <sub>max</sub> (dBW/MHz)																
100 kHz	100%	None	-118.00	3	10	30	13.1	3	30.0	65.9	0	3	3	0	0	0	0	-93.1	RQT	
20 MHz	100%	None	-145.00	3	10	30	13.1	3	30.0	65.9	0	3	3	0	0	0	0	-88.1	BL	
100 kHz	100%	50% Abs.	-121	3	10	30	13.1	3	30.0	65.9	0	3	3	0	0	0	0	-64.1	RQT	
1 MHz	100%	50% Abs.	-151	3	10	30	13.1	3	30.0	65.9	0	3	3	0	0	0	0	-94.1	RQR	
5 MHz	100%	50% Abs.	-151	3	10	30	13.1	3	30.0	65.9	0	3	3	0	0	0	0	-94.1	RQT	
20 MHz	100%	50% Abs.	-149.5	3	10	30	13.1	3	30.0	65.9	0	3	3	0	0	0	0	-92.6	RQT	
100 kHz	100%	OOK	-112	3	10	30	13.1	3	30.0	65.9	0	3	3	0	0	0	0	-55.1	DNBL	
20 MHz	100%	OOK	-137	3	10	30	13.1	3	30.0	65.9	0	3	3	0	0	0	0	-80.1	BL	
100 kHz	100%	2% Rel.	-119	3	10	30	13.1	3	30.0	65.9	0	3	3	0	0	0	0	-62.1	RQT	
1 MHz	100%	2% Rel.	-149	3	10	30	13.1	3	30.0	65.9	0	3	3	0	0	0	0	-92.1	RQT	
5 MHz	100%	2% Rel.	-149	3	10	30	13.1	3	30.0	65.9	0	3	3	0	0	0	0	-92.1	RQT	
20 MHz	100%	2% Rel.	-149.5	3	10	30	13.1	3	30.0	65.9	0	3	3	0	0	0	0	-92.6	RQT	
100 kHz	20%	None	-116.5	3	10	30	13.1	3	30.0	65.9	0	3	3	0	0	0	0	-59.6	DNBL	
20 MHz	20%	None	-148	3	10	30	13.1	3	30.0	65.9	0	3	3	0	0	0	0	-91.1	BL	
100 kHz	20%	50% Abs.	-116	3	10	30	13.1	3	30.0	65.9	0	3	3	0	0	0	0	-59.1	DNBL	
1 MHz	20%	50% Abs.	-132	3	10	30	13.1	3	30.0	65.9	0	3	3	0	0	0	0	-75.1	RQT	
5 MHz	20%	50% Abs.	-151	3	10	30	13.1	3	30.0	65.9	0	3	3	0	0	0	0	-94.1	RQT	
20 MHz	20%	50% Abs.	-148	3	10	30	13.1	3	30.0	65.9	0	3	3	0	0	0	0	-91.1	RQT	
100 kHz	20%	OOK	-118.5	3	10	30	13.1	3	30.0	65.9	0	3	3	0	0	0	0	-61.6	DNBL	
20 MHz	20%	OOK	-146	3	10	30	13.1	3	30.0	65.9	0	3	3	0	0	0	0	-89.1	BL	
100 kHz	20%	2% Rel.	-138	3	10	30	13.1	3	30.0	65.9	0	3	3	0	0	0	0	-81.1	RQT	
1 MHz	20%	2% Rel.	-134	3	10	30	13.1	3	30.0	65.9	0	3	3	0	0	0	0	-77.1	RQT	
5 MHz	20%	2% Rel.	-142.5	3	10	30	13.1	3	30.0	65.9	0	3	3	0	0	0	0	-85.6	RQT	
20 MHz	20%	2% Rel.	-143.5	3	10	30	13.1	3	30.0	65.9	0	3	3	0	0	0	0	-86.6	RQT	

BL - Break-lock

RQT - Reacquisition Time

DNBL - Did not break lock at the maximum UWB generator signal power

## B-12

### Operational Scenario: Surveying GPS Receiver and Multiple UWB Devices

#### GPS Receiver Architecture: Semi-Codeless

Broadband Noise		UWB												GPS Receiver Criteria														
UWB PRF	UWB Gating	Modulation	I <sub>max</sub> (dBW/MHz)	H <sub>gps</sub> (m)	H <sub>uw</sub> (m)	V <sub>sep</sub>	Theta #1 (deg)	D <sub>min</sub> #1 (m)	L <sub>p</sub> #1 (dB)	H <sub>sep</sub> #1 (m)	Theta #2 (deg)	D <sub>min</sub> #2 (m)	L <sub>p</sub> #2 (dB)	H <sub>sep</sub> #2 (m)	Theta #3 (deg)	D <sub>min</sub> #3 (m)	L <sub>p</sub> #3 (dB)	L <sub>pag</sub> (dB)	L <sub>ot</sub> (dB)	L <sub>all</sub> (dB)	L <sub>ma</sub> (dB)	L <sub>a</sub> (dB)	L <sub>b</sub> (dB)	L <sub>m</sub> (dB)	UWB EIRP (dBW/MHz)	RQT		
100 kHz	100%	None	-118.00	3	10	30	13.1	3	30.0	65.9	300.0	1.3	0	300.0	85.9	750	0.5	0	750	93.8	65.84	3.00	3	0	0	0	-93.2	RQT
20 MHz	100%	None	-145.00	3	10	30	13.1	3	30.0	65.9	300.0	1.3	0	300.0	85.9	750	0.5	0	750	93.8	65.84	3.00	3	0	0	0	-61.2	RQT
100 kHz	100%	50% Abs.	-121	3	10	30	13.1	3	30.0	65.9	300.0	1.3	0	300.0	85.9	750	0.5	0	750	93.8	65.84	3.00	3	0	0	0	-88.2	BL
1 MHz	100%	50% Abs.	-151	3	10	30	13.1	3	30.0	65.9	300.0	1.3	0	300.0	85.9	750	0.5	0	750	93.8	65.84	3.00	3	0	0	0	-64.2	RQT
5 MHz	100%	50% Abs.	-151	3	10	30	13.1	3	30.0	65.9	300.0	1.3	0	300.0	85.9	750	0.5	0	750	93.8	65.84	3.00	3	0	0	0	-94.2	RQT
20 MHz	100%	50% Abs.	-149.5	3	10	30	13.1	3	30.0	65.9	300.0	1.3	0	300.0	85.9	750	0.5	0	750	93.8	65.84	3.00	3	0	0	0	-94.2	RQT
100 kHz	100%	OOK	-112	3	10	30	13.1	3	30.0	65.9	300.0	1.3	0	300.0	85.9	750	0.5	0	750	93.8	65.84	3.00	3	0	0	0	-92.7	RQT
20 MHz	100%	OOK	-137	3	10	30	13.1	3	30.0	65.9	300.0	1.3	0	300.0	85.9	750	0.5	0	750	93.8	65.85	3.00	3	0	0	0	-55.2	DNBL
100 kHz	100%	2% Rel.	-119	3	10	30	13.1	3	30.0	65.9	300.0	1.3	0	300.0	85.9	750	0.5	0	750	93.8	65.85	3.00	3	0	0	0	-80.2	BL
1 MHz	100%	2% Rel.	-149	3	10	30	13.1	3	30.0	65.9	300.0	1.3	0	300.0	85.9	750	0.5	0	750	93.8	65.85	3.00	3	0	0	0	-62.2	RQT
5 MHz	100%	2% Rel.	-149	3	10	30	13.1	3	30.0	65.9	300.0	1.3	0	300.0	85.9	750	0.5	0	750	93.8	65.85	3.00	3	0	0	0	-92.2	RQT
20 MHz	100%	2% Rel.	-149.5	3	10	30	13.1	3	30.0	65.9	300.0	1.3	0	300.0	85.9	750	0.5	0	750	93.8	65.85	3.00	3	0	0	0	-92.2	RQT
100 kHz	20%	None	-116.5	3	10	30	13.1	3	30.0	65.9	300.0	1.3	0	300.0	85.9	750	0.5	0	750	93.8	65.85	3.00	3	0	0	0	-59.7	DNBL
20 MHz	20%	None	-148	3	10	30	13.1	3	30.0	65.9	300.0	1.3	0	300.0	85.9	750	0.5	0	750	93.8	65.85	3.00	3	0	0	0	-91.2	BL
100 kHz	20%	50% Abs.	-116	3	10	30	13.1	3	30.0	65.9	300.0	1.3	0	300.0	85.9	750	0.5	0	750	93.8	65.85	3.00	3	0	0	0	-59.2	DNBL
1 MHz	20%	50% Abs.	-132	3	10	30	13.1	3	30.0	65.9	300.0	1.3	0	300.0	85.9	750	0.5	0	750	93.8	65.85	3.00	3	0	0	0	-75.2	RQT
5 MHz	20%	50% Abs.	-151	3	10	30	13.1	3	30.0	65.9	300.0	1.3	0	300.0	85.9	750	0.5	0	750	93.8	65.85	3.00	3	0	0	0	-94.2	RQT
20 MHz	20%	50% Abs.	-148	3	10	30	13.1	3	30.0	65.9	300.0	1.3	0	300.0	85.9	750	0.5	0	750	93.8	65.85	3.00	3	0	0	0	-91.2	RQT
100 kHz	20%	OOK	-118.5	3	10	30	13.1	3	30.0	65.9	300.0	1.3	0	300.0	85.9	750	0.5	0	750	93.8	65.85	3.00	3	0	0	0	-61.7	DNBL
20 MHz	20%	OOK	-146	3	10	30	13.1	3	30.0	65.9	300.0	1.3	0	300.0	85.9	750	0.5	0	750	93.8	65.85	3.00	3	0	0	0	-89.2	BL
100 kHz	20%	2% Rel.	-138	3	10	30	13.1	3	30.0	65.9	300.0	1.3	0	300.0	85.9	750	0.5	0	750	93.8	65.85	3.00	3	0	0	0	-81.2	RQT
1 MHz	20%	2% Rel.	-134	3	10	30	13.1	3	30.0	65.9	300.0	1.3	0	300.0	85.9	750	0.5	0	750	93.8	65.85	3.00	3	0	0	0	-77.2	RQT
5 MHz	20%	2% Rel.	-142.5	3	10	30	13.1	3	30.0	65.9	300.0	1.3	0	300.0	85.9	750	0.5	0	750	93.8	65.85	3.00	3	0	0	0	-85.7	RQT
20 MHz	20%	2% Rel.	-143.5	3	10	30	13.1	3	30.0	65.9	300.0	1.3	0	300.0	85.9	750	0.5	0	750	93.8	65.85	3.00	3	0	0	0	-86.7	RQT

BL Break-lock

RQT - Reacquisition Time

DNBL - Did not break lock at the maximum UWB generator signal power

**Operational Scenario: Aviation GPS Receiver Non-Precision Approach and Multiple UWB Devices**

**GPS Receiver Architecture: C/A-code**

Broadband Noise			I <sub>max</sub> (dBW/MHz)	H <sub>gps</sub> (m)	H <sub>uw</sub> (m)	G <sub>r</sub> (dBfc)	D <sub>min</sub> (m)	L <sub>p</sub> (dB)	L <sub>mult</sub> (dB)	L <sub>allot</sub> (dB)	L <sub>man</sub> (dB)	L <sub>a</sub> (dB)	L <sub>b</sub> (dB)	L <sub>s</sub> (dB)	UWB EIRP (dBW/MHz)	GPS Receiver Criteria
			-134.5	41.4	3	-10	41.4	68.7	6	10	3	0	0	6	-80.8	RQT
UWB PRF	UWB Gating	UWB Mod.	I <sub>max</sub> (dBW)	H <sub>gps</sub> (m)	H <sub>uw</sub> (m)	G <sub>r</sub> (dBfc)	D <sub>min</sub> (m)	L <sub>p</sub> (dB)	L <sub>mult</sub> (dB)	L <sub>allot</sub> (dB)	L <sub>man</sub> (dB)	L <sub>a</sub> (dB)	L <sub>b</sub> (dB)	L <sub>s</sub> (dB)	UWB EIRP (dBW)	
1 MHz	100%	None	-143.7	41.4	3	-10	41.4	68.7	0	10	3	0	0	6	-84.0	BL
5 MHz	100%	None	-145.5	41.4	3	-10	41.4	68.7	0	10	3	0	0	6	-85.8	BL
20 MHz	100%	None	-145	41.4	3	-10	41.4	68.7	0	10	3	0	0	6	-85.3	BL
5 MHz	20%	None	-145.2	41.4	3	-10	41.4	68.7	0	10	3	0	0	6	-85.5	BL
20 MHz	20%	None	-145.8	41.4	3	-10	41.4	68.7	0	10	3	0	0	6	-86.1	BL
5 MHz	100%	OOK	-144.5	41.4	3	-10	41.4	68.7	0	10	3	0	0	6	-84.8	BL
20 MHz	100%	OOK	-144.5	41.4	3	-10	41.4	68.7	0	10	3	0	0	6	-84.8	BL
5 MHz	20%	OOK	-144.2	41.4	3	-10	41.4	68.7	0	10	3	0	0	6	-84.5	BL
20 MHz	20%	OOK	-146.3	41.4	3	-10	41.4	68.7	0	10	3	0	0	6	-86.6	BL
UWB PRF	UWB Gating	UWB Mod.	I <sub>max</sub> (dBW/MHz)	H <sub>gps</sub> (m)	H <sub>uw</sub> (m)	G <sub>r</sub> (dBfc)	D <sub>min</sub> (m)	L <sub>p</sub> (dB)	L <sub>mult</sub> (dB)	L <sub>allot</sub> (dB)	L <sub>man</sub> (dB)	L <sub>a</sub> (dB)	L <sub>b</sub> (dB)	L <sub>s</sub> (dB)	UWB EIRP (dBW/MHz)	GPS Receiver Criteria
100 kHz	100%	None	-112.6	41.4	3	-10	41.4	68.7	0	10	3	0	0	6	-52.9	BL
100 kHz	20%	None	-106.5	41.4	3	-10	41.4	68.7	0	10	3	0	0	6	-46.8	DNBL
1 MHz	20%	None	-134.5	41.4	3	-10	41.4	68.7	6	10	3	0	0	6	-80.8	NRQT
100 kHz	100%	OOK	-102.6	41.4	3	-10	41.4	68.7	0	10	3	0	0	6	-42.9	DNBL
1 MHz	100%	OOK	-134.5	41.4	3	-10	41.4	68.7	6	10	3	0	0	6	-80.8	NRQT
100 kHz	20%	OOK	-109.4	41.4	3	-10	41.4	68.7	0	10	3	0	0	6	-49.7	DNBL
1 MHz	20%	OOK	-134.5	41.4	3	-10	41.4	68.7	6	10	3	0	0	6	-80.8	NRQT
100 kHz	100%	50% Abs.	-100	41.4	3	-10	41.4	68.7	0	10	3	0	0	6	-40.3	DNBL
1 MHz	100%	50% Abs.	-134.5	41.4	3	-10	41.4	68.7	6	10	3	0	0	6	-80.8	NRQT
5 MHz	100%	50% Abs.	-137	41.4	3	-10	41.4	68.7	6	10	3	0	0	6	-83.3	RQT
20 MHz	100%	50% Abs.	-138	41.4	3	-10	41.4	68.7	6	10	3	0	0	6	-84.3	RQT
100 kHz	100%	2% Rel.	-100	41.4	3	-10	41.4	68.7	0	10	3	0	0	6	-40.3	DNBL
1 MHz	100%	2% Rel.	-134.5	41.4	3	-10	41.4	68.7	6	10	3	0	0	6	-80.8	NRQT
5 MHz	100%	2% Rel.	-136.5	41.4	3	-10	41.4	68.7	6	10	3	0	0	6	-82.8	RQT
20 MHz	100%	2% Rel.	-136	41.4	3	-10	41.4	68.7	6	10	3	0	0	6	-82.3	RQT
100 kHz	20%	50% Abs.	-107	41.4	3	-10	41.4	68.7	0	10	3	0	0	6	-47.3	DNBL
1 MHz	20%	50% Abs.	-134.5	41.4	3	-10	41.4	68.7	6	10	3	0	0	6	-80.8	NRQT
5 MHz	20%	50% Abs.	-134.5	41.4	3	-10	41.4	68.7	6	10	3	0	0	6	-80.8	NRQT
20 MHz	20%	50% Abs.	-134.5	41.4	3	-10	41.4	68.7	6	10	3	0	0	6	-80.8	NRQT
100 kHz	20%	2% Rel.	-107	41.4	3	-10	41.4	68.7	0	10	3	0	0	6	-47.3	DNBL
1 MHz	20%	2% Rel.	-134.5	41.4	3	-10	41.4	68.7	6	10	3	0	0	6	-80.8	NRQT
5 MHz	20%	2% Rel.	-134.5	41.4	3	-10	41.4	68.7	6	10	3	0	0	6	-80.8	NRQT
20 MHz	20%	2% Rel.	-134.5	41.4	3	-10	41.4	68.7	6	10	3	0	0	6	-80.8	NRQT

BL - Break-lock

RQT - Reacquisition Time

DNBL - Did not break lock at the maximum UWB generator signal power

NRQT - Broadband Noise Reacquisition

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	
1	Transmitter			Path Loss				Receive Antenna								
2	uV/m/MHz	@ R(m)		Free Space	Continental Temperate	Okumura			bw(deg)	Gain(dBi)	Const	OMNI		V	H	
3	500	3	(●) field st	Tirem & ITM	Flat				515.74	-10	(●)	Beamwidth				
4	-41.278	-40	(○) EIRP	Average Ground	10%,50%,50				180	-0.857	(○)	horiz/conical	60	back lobe	elev(deg)	
5	FREQ	1575.42		General				Mode	Parameterize	h(km)	NF(dB)	System Losses	Smin(dBm)	Other(dBm/MHz)	Ring Spacing	
6	RIN	0	(●) maxls	Calculate	EIRP[I/N]	Altitude				3	-10				10 meter	
7	ROUT	20	(○) ROUT	<input checked="" type="checkbox"/> Iagg+Isingle	6.17723	-69.752	0		3	-110.98	dB	0.15	<input type="checkbox"/> I other	<input type="checkbox"/> Make trace file?		
8				Criteria(dB)	MxSnglEirp	@R(km)		tranht(m)	N(dBm/MHz)			B <sub>E</sub> (MHz)				
9																
10																
11																
12																
13																
14																
15																
16																
17																
18																
19																
20																
21																
22																
23									0.03	0.1	0.1	0.3048				
24									1	-69.882	-59.962	-59.962	-53.651		-104.8 Imax(dBm)	
25									10	-70.9	-64.096	-64.096	-63.651		6.17723	
26									200	-77.569	-77.107	-77.107	-76.661			
27									1000	-84.558	-84.096	-84.096	-83.651			
28									10000	-94.558	-94.096	-94.096	-93.651			
29										(●)	(○)	(○)	(○)			
30																

Operational Scenario: En-route Navigation and indoor UWB Device Operation

MAX EIRP (dBm/MHz)

Active Emitters/km<sup>2</sup>

h (km)

0.3048

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1	Transmitter			Path Loss			Receive Antenna								
2	uv/m/MHz	@ R(m)		Free Space	Continental Temperat	Okumura	bw(deg)	Gain(dBi)	Const	OMNI	V	H			
3	500	3	( field st	Tirem & ITM	Flat		515.74	-10	(	Beamwidth				elev(deg)	
4	-41.278	-40	( EIRP	Average Ground	10%,50%,50		180	-0.857	(	horiz/conical	60	back lobe			back lobe
5	FREQ	1575.42		General			h(km)	NF(dB)	System Losses	Smin(dBm)	Other(dBm/MHz)	Ring Spacing			
6	RIN	0	( maxvis	Mode	Parameterize		3	-19			10 meter				
7	ROUT	20	( ROUT	Calculate	EIRP[I/N]	Altitude									
8					Criteria(dB)	MxSnglEirp	@R(km)	tranht(m)	N(dBm/MHz)						Make trace file?
9															Radar Altimeter
10															Pt(dBm)
11															
12															Ant Sep(ft)
13															Type
14															( Pulsed
15															( CW
16															
17															Pls wdth(sec)
18															
19															Pr(dBm/MHz)
20															
21															Use Alt Smin?
22															
23							0.03	0.1	0.1	0.3048					
24					(	1	-78.882	-68.962	-68.962	-62.651		-104.8	Imax(dBm)		
25					(	10	-79.9	-73.096	-73.096	-72.651		6.17723			
26					(	200	-86.569	-86.107	-86.107	-85.661					
27					(	1000	-93.558	-93.096	-93.096	-92.651					
28					(	10000	-103.56	-103.1	-103.1	-102.65					
29							(	(	(	(					
30															

Operational Scenario: En-route Navigation and outdoor UWB Device Operation

MAX EIRP (dBW/MHz)

Active Emitters/km<sup>2</sup>

h (km)

0.3048

# Measurements to Determine Potential Interference to GPS Receivers from Ultrawideband Transmission Systems



*report series*

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# **Measurements to Determine Potential Interference to GPS Receivers from Ultrawideband Transmission Systems**

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Michael G. Cotton  
Robert J. Achatz  
Richard N. Statz  
Roger A. Dalke**



**U.S. DEPARTMENT OF COMMERCE  
Donald L. Evans, Secretary**

**John F. Sopko, Acting Assistant Secretary  
for Communications and Information**

**February 2001**

### **Product Disclaimer**

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## CONTENTS

	Page
<b>ABSTRACT . . . . .</b>	<b>1-1</b>
<b>1. INTRODUCTION . . . . .</b>	<b>1-1</b>
<b>1.1 The Technologies . . . . .</b>	<b>1-2</b>
<b>1.1.1 Global Positioning System . . . . .</b>	<b>1-2</b>
<b>1.1.2 Ultrawideband Transmission Systems . . . . .</b>	<b>1-2</b>
<b>1.2 Brief History of GPS versus UWB Compatibility Measurements . . . . .</b>	<b>1-3</b>
<b>1.3 Scope . . . . .</b>	<b>1-3</b>
<b>1.4 Organization of this Report . . . . .</b>	<b>1-4</b>
<b>2. SIGNAL CHARACTERISTICS . . . . .</b>	<b>2-1</b>
<b>2.1 GPS . . . . .</b>	<b>2-1</b>
<b>2.2 UWB . . . . .</b>	<b>2-1</b>
<b>3. GENERAL MEASUREMENT METHODOLOGIES . . . . .</b>	<b>3-1</b>
<b>3.1 Interference Characterization . . . . .</b>	<b>3-1</b>
<b>3.2 Operational Testing . . . . .</b>	<b>3-2</b>
<b>3.3 Observational Testing . . . . .</b>	<b>3-2</b>
<b>4. MEASUREMENT SYSTEM AND PROCEDURES . . . . .</b>	<b>4-1</b>
<b>4.1 System . . . . .</b>	<b>4-1</b>
<b>4.1.1 GPS-Source Segment . . . . .</b>	<b>4-3</b>
<b>4.1.2 UWB-Source Segment . . . . .</b>	<b>4-4</b>
<b>4.1.3 GPS-Receiver Segment . . . . .</b>	<b>4-9</b>
<b>4.2 Power Measures, Settings and Calibration . . . . .</b>	<b>4-10</b>
<b>4.2.1 Carrier-to-Noise Density Ratio Settings . . . . .</b>	<b>4-10</b>
<b>4.2.2 Calibration and Power Level Correction . . . . .</b>	<b>4-11</b>
<b>4.3 Measurement Procedure . . . . .</b>	<b>4-12</b>
<b>5. DATA ANALYSIS . . . . .</b>	<b>5-1</b>
<b>5.1 UWB Signal Characterization . . . . .</b>	<b>5-1</b>
<b>5.2 Operational Metrics . . . . .</b>	<b>5-3</b>
<b>5.2.1 Break-lock Point . . . . .</b>	<b>5-3</b>
<b>5.2.2 Reacquisition Time . . . . .</b>	<b>5-3</b>
<b>5.3 Observational Metrics . . . . .</b>	<b>5-4</b>
<b>5.3.1 Range Performance . . . . .</b>	<b>5-4</b>
<b>5.3.2 Cycle Slip and Signal-to-Noise Ratio . . . . .</b>	<b>5-16</b>
<b>5.4 Uncertainty Analysis . . . . .</b>	<b>5-19</b>
<b>5.4.1 Break-lock Point . . . . .</b>	<b>5-19</b>

5.4.2 RQT .....	5-19
5.4.3 Range Error .....	5-19
5.4.4 Cycle Slip Conditions .....	5-21
6. RESULTS .....	6-1
6.1 UWB Spectral and Temporal Characteristics .....	6-1
6.2 GPS Interference Measurement Results .....	6-4
6.3 Summary of Measurement Results .....	6-14
7. CONCLUSION .....	7-1
8. ACKNOWLEDGMENTS .....	8-1
9. REFERENCES .....	9-1
10. GLOSSARY .....	10-1
APPENDIX A: CONDUCTED VERSUS RADIATED PATH MEASUREMENTS .....	A-1
APPENDIX B: HARDWARE SPECIFICATION .....	B-1
APPENDIX C: CHARACTERISTICS OF GENERATED UWB SIGNALS .....	C-1
APPENDIX D: THEORETICAL ANALYSIS OF UWB SIGNALS USING BINARY PULSE-MODULATION AND FIXED TIME-BASE DITHER .....	D-1
APPENDIX E: TUTORIAL ON USING AMPLITUDE PROBABILITY DISTRIBUTIONS TO CHARACTERIZE THE INTERFERENCE OF ULTRAWIDEBAND TRANSMITTERS TO NARROWBAND RECEIVERS .....	E-1
APPENDIX F: GPS PERFORMANCE MEASUREMENT RESULTS .....	F-1